Not to be cited without the
permission of the author(s)[1]

Canadian Atlantic Fisheries
Scientific Advisory Committee

CAFSAC Research Document 90/17

Ne pas citer sans
autorisation des auteur(s)[1]

Comité scientifique consultatif des
pêches canadiennes dans l'Atlantique

CSCPCA Document de recherche 90/ 17

Scallop Fishing Grounds on the Scotian Shelf - 1989

By

G. Robert, M.J. Lundy, and M.A.E. Butler-Connolly
Benthic Fisheries and Aquaculture Division
Biological Sciences Branch
Halifax Fisheries Research Laboratory
Department of Fisheries and Oceans
Scotia-Fundy Region
P. O. Box 550
Halifax, N. S.
B3J 2S7

[1]This series documents the scientific basis for fisheries management advice in Atlantic Canada. As such, it addresses the issues of the day in the time frames required and the Research Documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research Documents are produced in the official language in which they are provided to the Secretariat by the author(s).

[1]Cette série documente les bases scientifiques des conseils de gestion des pêches sur la côte atlantique du Canada. Comme telle, elle couvre les problèmes actuels selon les échéanciers voulus et les Documents de recherche qu'elle contient ne doivent pas être considérés comme des énoncés finals sur les sujets traités mais plutôt comme des rapports d'étape sur les études en cours.

Les Documents de recherche sont publiés dans la langue officielle utilisée par les auteur(s) dans le manuscrit envoyé au secrétariat.

ABSTRACT

Once again in 1989 scallop beds from the Scotian Shelf have contributed in an important way (20 %) to the total landings of the deep-sea fleet. 1989 witnessed the return of Browns Bank to significant exploitation levels in addition to the sustained production from the Western Bank / Sable Island area.

Actually, the 500+ t caught in 1989 rank the year as an excellent one over the short catch history of the eastern Scotian Shelf. Production established from catch has also been sustained for the last 9 years. Catch-rates are low to moderate compared to other areas exploited by the deep-sea fleet but the 1989 CPUE, 0.27 kg / crhm, was the highest on record for this area. The 1989 stock survey repeated trends observed previously: a relatively important abundance at age with sizable quantities of pre-recruits and a few recruits as well.

The experimental fishery conducted on the western Scotian Shelf with a size limit at 55 meats per 500 g, different from the Georges Bank one, and a quota set by industry allowed a rationalised exploitation of scallop beds that would not have been realised otherwise. This exercise has shown the feasibility of having the western Scotian Shelf under a management plan different from the one of its more important neighbour, Georges Bank. Over 90 % of the 350 t catches came from a very small area on the northern side of Browns Bank. Best catch-rates were 0.66 kg / crhm (Browns) and 0.78 kg / crhm (Tusket). About 5 t were caught on German Bank at a moderate CPUE. There are no recent stock surveys for this area.

RESUME

Une fois de plus, en 1989, les bancs pétoncliers du plateau néo-écossais ont contribué de façon importante (20 %) aux débarquements totaux de la flotte hauturière. 1989 a marqué le retour du banc Browns à des niveaux d'exploitation significatifs en plus de la production soutenue de la région Western Bank / Sable Island.

En fait, les quelques 500 t capturées sur le plateau néo-écossais de l'Est en 1989 classifient cette année parmi une des meilleures de la courte histoire de cette partie du plateau. La production telle qu'établie par les prises a aussi été soutenue durant les 9 dernières années. Les taux de capture vont de bas à modéré comparé aux autres régions exploitées par la flotte hauturière mais le taux de capture pour 1989, 0.27 kg / crhm, était le plus haut enregistré pour ces bancs. L'inventaire de recherche de 1989 répéta des patrons observés précédemment: une abondance à l'âge relativement importante avec des quantités appréciables de pré-recrues et aussi des recrues.

La pêche expérimentale qui a eu lieu sur le plateau néo-écossais de l'Ouest avec un compte de chairs de 55 par 500 g, différent de celui pour le banc Georges et un quota établi par l'industrie a permis une exploitation rationelle de bancs pétoncliers qui n'aurait pas été possible autrement. Cet exercise a démontré la possibilité d'avoir un plan de gestion propre au plateau néo-écossais de l'Ouest et différent de celui de son important voisin, le banc Georges. Plus de 90 % des prises de 350 t proviennent d'une très petite région sur le côté nord du banc Browns. Les meilleurs taux de capture varient de 0.66 kg / crhm (Browns) à 0.78 kg / crhm (Tusket). Environ 5 t ont été capturées sur le banc German avec un taux de capture moyen. Il n'y a pas d'inventaire de stocks récent pour cette région.

105-02442/

INTRODUCTION

The traditional fishing patterns of the deep-sea fleet have always included Georges Bank as the main ground exploited with scallop beds on the Scotian Shelf as alternates (Fig. 1), sometimes in an opportunistic fashion. Scotian Shelf scallop beds have been visited more regularly since fishing activities on Georges Bank have been restricted to the zone east of the ICJ line (Oct. 1984) and are directed by an Enterprise Allocations system (E.As.) for catch removals. Ever since the beginning of the offshore fishery in the late 1950's, exploitation of the Scotian Shelf was somewhat irregular. That pattern of exploitation has changed with the 1980's. It now appears that some Scotian Shelf grounds may sustain continuous exploitation.

After very little fishing activity west of longitude 65 ° W for the last 4 years, an 'experimental' fishery in the Browns Bank area in late summer of 1989 yielded nearly 350 t. The Sable Island / Western Bank area provided catches over 500 t in 1989; such values are in the high range for NAFO SA 4W.

METHODS

Fishery Information

There are two sources of information to estimate the respective fishery contributions of scallop fishing grounds on the Scotian Shelf. The Statistics Division, Department of Fisheries and Oceans, Halifax, compiles, on a yearly basis, landings by vessel size and by NAFO sub-subareas. Log information as to the origin of the catch provided by vessels is the other source. There are at times discrepancies between statistical and logged catches as NAFO sub-subareas are not tailored to the physical location of particular scallop beds and may cut a major scallop bed in two. This inadequacy of the statistics system was previously described in Robert et al (1984). The separation of the fleets (1987 onward) at latitude 43^0 40' N is adding another dimension to the inadequacy of the statistical reporting system. Lurcher Shoals have scallop beds spreading both north and south of latitude 43^0 40' N so that scallop catches statistically compiled in NAFO sub-subarea 4Xq may still originate from the inshore and / or offshore fleets. One must assume the catches from vessels under 19.8 m come from the upper reaches of the Lurcher Shoals (north of the separation line) while vessels over 19.8 m fish German Bank and the lower Lurcher Shoals (south of the line). Fortunately, little fishing activity is presently taking place in this area. In 1989, only 5 t were caught on German Bank.

All vessels (over 25.5 G.T. or 14 m L.O.A.) fishing the Scotian Shelf are required to keep logbooks to record daily fishing activities. Daily log records supply information on the catch and its location and fishing effort such as hours spent fishing, width of gear, and number of crew (crhm). Catch-rate estimates may be computed when complete effort data (location, hours fished, gear, etc.) are provided with respect to the catch (Class 1 data). Total effort may be estimated according to the effort that generated the Class 1 catch. The productivity in terms of removals of a specific ground may also be established assuming that the catch with known location is representative of the total catch from that ground.

Scallop Fleets

Two components of the Canadian offshore fleet may drag for scallops on the Scotian Shelf. The deep-sea fleet, L.O.A. over 19.8 m is excluded from a 12 nautical miles zone near-shore and waters in the Bay of Fundy and approaches north of latitude 43^0 40' N following the Inshore / Offshore Agreement. The Bay of Fundy fleet, mostly L.O.A. between 14 and 19.8 m (Bay of Fundy

licensed vessels), has to restrict its activities on the Scotian Shelf to the upper parts of the Lurcher Shoals between latitudes 43^0 40' and 44^0 00' N following the Agreement.

Despite the different size of vessels, both fleets use an offshore-type scallop drag which width may vary from 2.4 to 4.9 m (8-16 feet). The Bay of Fundy fleet fishes only one drag at a time while the deep-sea fleet fishes two drags simultaneously, one on each side. These are slightly wider than the ones used by the Bay of Fundy fleet. On occasion, a Bay of Fundy vessel may use a gang of Digby-type drags.

Catch Sampling

Catch sampling information is available for the deep-sea fleet only. Port coverage varies greatly, from none for southwest Nova Scotia ports like Yarmouth and Saulnierville to somewhat fair in the Lunenburg - Riverport area. However, since the exploitation of scallop grounds on the Scotian Shelf was somewhat irregular until very recently, sampling of the catch is rather sporadic and does not meet target levels to sample the catch adequately.

Survey Procedures on the Scotian Shelf

The catch distribution derived from log records for each particular fishing ground is used to randomly stratify survey stations. Catches from the deep-sea fleet over the year prior to the survey are considered. Annual surveys are carried out during May on a Government research vessel. The Browns Bank and German / Lurcher segments of the Scotian Shelf annual stock survey have been dropped a few years ago due to the low levels of fishing activity.

The survey gear was a 2.44 m wide New Bedford offshore dredge (75-mm ring size) lined with 38-mm stretch mesh polypropylene netting. Tows were of ten minutes duration; distance towed was determined either from Loran C bearings, at start-end of tow, or from continuous recording via a desk-top computer. Catches were later standardised to a tow length of 800 m. For each tow, the following data were recorded: 1) shell heights in 5-mm intervals for all live scallops and cluckers (shells with both valves still attached at the hinge); 2) tow location with Loran C bearings; 3) depth (m); 4) compass bearing for direction of tow; 5) duration of tow in minutes; 6) substrate type; 7) fullness of the drag (count of the number of vertical rings covered by the catch); and 8) total scallop catch as a round weight.

In addition to establishing a stratified mean number per tow, the data was contoured to represent the spatial distribution of the scallop aggregations. Abundance estimates are also derived. Data points describe a three dimensional surface with latitude, longitude, and number per tow to be plotted. A surface is formed by defining Delaunay triangles from an algorithm found in Watson (1982); the data points become the vertices of triangles connecting neighbour points. The surface between adjacent contour levels, in this case the abundance of scallops, is represented as darkening shades of grey. Contours may be smoothed by interpolating the surface by inverse weighing of gradients (slopes of triangles). The sides of the Delaunay triangles are divided into equal segments (chords) to establish the interpolation points. For example, dividing the sides into 4 segments gives 16 subtriangles. The interpolation points become new vertices. This method assumes that the data points near the point in question contribute more than distant points (see also Watson and Philip 1985). Each triangle is assumed to have a flat surface. The summation of the volumes of all triangles under the contoured surface is equal to the total volume, here the abundance estimate for the survey area. The degree of interpolation will affect the volume estimates. Experimental work indicates that volume estimates stabilise with a minimum of variation (5 %) after 16 or more subtriangles. A complete description may be found in Black (MS 1988).

Relevant Biological Information

Biological information dealing only with growth-rate and meat weight on shell height allometry are given here. Biological data has been gathered since 1982 as part of an on-going study of somatic and gonadal growth cycles.

Recently, areas such as Sable Island - Western Bank have better sampling coverage from the commercial fleet than the Browns Bank area where little fishing activity has taken place.

Samples from 1982 to 1989 surveys and samples collected from the fleet up to 1989 were used in the analysis. Table 1 presents variables of von Bertalanffy growth curves and the number of scallop shells that have been ring-read for each area. It also gives the regression parameters for estimating meat yield as a function of shell height and the number of animals examined. In an attempt to reduce seasonal effects in yield conditions, samples collected at all times of the year have been included in the analysis to approximate a 'year round' value. With a small sample from Banquereau Bank collected during the stock surveys some biological information was tentatively derived until more material is collected. The Sable Island area presents a wide range of depths (20 - over 100 m) where scallop concentrations occur, leading to a great deal of heterogeneity in growth patterns. However, all data were pooled together to generate one equation for the area.

RESULTS

Scallop Fleets

Previous to 1984, over 100 vessels from the deep-sea fleet and the Bay of Fundy fleet were exploiting scallop grounds on the Scotian Shelf (Table 2). This activity declined during 1984, 1985 to increase again in 1986. Following the Inshore / Offshore Agreement, the Bay of Fundy fleet was restricted to a very small section of the Shelf and only one vessel fished the area according to the information available. The deep-sea fleet activities have steadily declined to a low of 17 vessels in 1988 before picking up in 1989 to 35 vessels.

For both fleets, the Scotian Shelf fishery is not a feature as permanent as the Georges Bank fishery for the deep-sea fleet and the traditional scallop grounds within the Bay of Fundy for the Bay of Fundy fleet. With Georges Bank catch removals now limited under an enterprise allocation system the deep-sea fleet is shifting some of the traditional effort to scallop grounds on the Scotian Shelf in NAFO subareas 4V and 4W. Catch-rates in NAFO 4W have usually been below average (especially compared to Georges Bank rates). In 1989 an experimental fishery got underway in NAFO SA 4X on German / Lurcher, Browns Bank and its northern approaches (Tusket area). Total statistical catches of 350 t approximately were recorded and catch-rates were well above average, 0.780 kg/crhm for Tusket (NAFO sub-subarea 4Xo).

To give methodical coverage to all fishing areas (Fig. 1) (from east to west), each area is looked at with respect to: a fishery profile, an estimate of its productivity in terms of distribution of scallop beds and abundance, catch sampling, and survey results.

Banquereau Bank

Historically speaking, Banquereau Bank (NAFO subarea 4V) has never been reported as a scallop-producing area, catches averaging less than 10 t per year (Table 3). It is a natural geographical extension of Sable Island Bank to the east. Highest landings (16 t) were reported in 1986. But this trend could not be maintained according to the 1987 figure of under 1 t with a 50 % drop in CPUE. Official statistics do not report any catches for 1988 or 1989. These catches have also originated from TMS (Ten Minute Square) on Banquereau Bank adjacent to Sable Island Bank. Catch levels and the profile of catch-rates thus far do not indicate the presence of an important stock biomass.

The 6 exploratory tows carried out on Banquereau Bank (Table 4) in 1989 indicated as in previous surveys the extremely low abundance (Table 5); furthermore, the most recent survey suggests the presence of only the oldest age class. Prerecruits were absent in the lined gear (Table 9).

Middle Ground

Middle Ground is a shallow bank of which 500 square nautical miles carries commercial densities of scallops. Scallop production has been fairly sporadic with a 100 % increase in catches from 1985 to 1986 followed by a serious drop thereafter (Table 6). Catch-rates had been moderate at best, 0.5 kg/crhm in 1982, to decline gradually to an average of 0.15 between 1986-89. Over 20 t landed in 1989 bring a significant improvement to the area catch profile. CPUE at 0.326 kg/crhm is also one of the best ever recorded.

Sampling of the catch (Table 7) indicates that a wide range of meats are shucked with a relatively large mean weight. This profile varies little between years although only a small number of meats are weighted. Very low catches in 1988 prevented catch sampling. In 1989 there was an important weight drop (33 %) in the average meat, from 21.4 to 14.4 g.

Stock surveys (tables 4, 8-9) had shown low abundance of scallops at age except for the first survey in 1983. The prerecruit index rose significantly in 1988 but overall mean numbers at age are very low. This information is presented for reference only; the 1989 Scotian Shelf stock survey did not carry any sampling on Middle Grounds given the little fishery performance in 1988.

Sable Island/Western Bank

When the deep-sea fleet began to fish scallop grounds in the Sable Island area in 1980, it confined itself to a small area of Western Bank, at the edge of the continental shelf within the 100-m isobath (Fig. 1). Gradually, fishing activities extended their range not only along the edge of the shelf (in a northeasterly direction) but also over Western Bank, Sable Island Bank, and in the immediate vicinity of Sable Island up to Banquereau Bank (NAFO sub sub-areas 4Wf, g, h, j, l, and u designated here under the label of SA 4Wf-j). Annual catches have been low (Table 6) until 1986 (1983 excepted) when a sharp, 10 fold increase occurred from 1985 to 1986. After a decline in catches during 1987 and 1988, the 1989 catches were the second highest, 516 t. Effort expanded, around 1.9 millions crew-hour-meters, produced excellent catch-rates at 0.267 kg/crhm. In comparison to the more productive Georges Bank, the 1989 CPUE for Sable/Western is in the low range.

Except for 1985, the mean weight of scallop meats shucked has been considerably smaller than in neighboring Middle Grounds, (Table 7) 12 versus 20+ g. The 1987 catch sampling recorded the smallest and largest shucked scallop since the fishery began in 1980 (2 - 98 g). About 50 % of the catch was scallops between 7 and 10 years of age, a fair mix of year-classes but the growth pattern of this area is complex. In 1989 the size distribution of the catch was fairly typical (Table 7) of the historical profile for the area.

Since the start of annual stock surveys five years ago, the 1988 survey had observed the second greatest abundance at age (Table 10) with sizable quantities of prerecruits and quite a few recruits as well (Table 11), especially young recruits (ages 5-6). The 1989 survey reported similar trends with an improvement in the low stratum.

The distributions and relative densities (numbers at age per standard tow) of selected age groups by shaded contours are plotted in Figs 2 - 5. The area surveyed is not exactly duplicated in its physical dimensions from year to year and varies between 4,000 to 6,000 square km (Table 12). The fishing fleet, in its first years, was exploring for new grounds and shifted effort from one scallop bed to another. Therefore, it was not necessarily covering all available grounds; 1986 is a case in point (see also Robert et al 1987). There is also a small scallop bed to the north of Sable Island that attracts fishing interest from time to time. Each contour plot shows that high abundances are to be found mainly near the edge of the continental shelf rather than on Western Bank per se or in the immediate vicinity of Sable Island. In addition, the area where important concentrations are found is very limited geographically speaking, less than 1,500 sq. km.

Abundance at age estimates ($n*10^6$) (Table 13) were derived by integrating the volumes

under the contoured surfaces. Contours were smoothed by subtriangulation (16) of the surface. The volume estimates show the gradual rise in abundance of scallops in the Western Bank area with a fairly large component of recruits. These estimates follow the same general trends than the relative catch-rates in table 10. Such catch-rates would suggest relatively good fishing performance over the next year.

No correction is made for the efficiency of the gear. Gear behaviour has not been studied on these particular grounds. But if one was to assume the figure for other grounds valid here, the factor involved could be in the order of 5-10 X.

Browns Bank/Tusket Area

Scallop aggregations, when commercially important, are found along the southern edge of Browns Bank (NAFO sub-subarea 4Xp) around the 100-m isobath and on the northern side of the Bank (Tusket, NAFO sub-subarea 4Xo) but in much deeper waters.

These scallop beds used to be exploited by both fleets, the deep-sea fleet landing more than the Bay of Fundy fleet except in 1986; Table 14 has data for the deep-sea fleet. Despite discrepancies between statistical landings and logged catches, the scallop production from the Browns Bank area has decreased erratically.There has been a small resurgence of landings in 1988 with very high catch-rates at 1.8 kg/crhm.

At industry's request, steps were initiated in 1989 to undertake an experimental fishery in NAFO SA 4X covering Browns Bank, Tusket and German / Lurcher scallop grounds. Although there was no indication of important recruitment from past available research surveys, biomass had had an opportunity to accumulate because of the low fishing effort in previous years. The low activity partially resulted from the management plan grouping both the fast growing Georges Bank stock and the slowest Browns Bank's under the same meat count regime. The 33 meats per 500 g regime contributes to yield optimisation on Georges Bank but does not reciprocate to the same extent for the stocks of Browns, Tusket or German / Lurcher because of different growth-rates and allometric relationships (shell height-meat weight), all lower than the ones for Georges Bank. The experimental fishery stipulated a meat count of 55 per 500 g was to be adhered to until a quota of 400 t was caught. The quota was arrived at by industry members of the Offshore Scallop Advisory Committee. This meat count is an improvement, to allow exploitation of these scallop beds although it is not necessarily an optimum figure.

The fishery took place from September for 6 weeks until meats were so small that catch-rates dropped and crews complained that shucking had become quite tedious. Actually some vessels had started fishing the area in June but under the Georges Bank management plan (33 meats per 500 g, entreprise alocations, etc.); pre-September catches amounted to about 30 % of the total.

Figure 6 maps the distribution of logged catches and CPUE on a Ten-Minute Square (TMS) basis. Over 90 % of the catches came from a very small area of the northern side of Browns Bank overlapping SA 4Xp and 4Xo. The area of interest corresponds to the shaded rectangle in fig. 6. The Tusket area had the highest mean CPUE (Table 14) but Browns Bank was still adequate at 0.660 kg/crhm. A few vessels explored other beds on the southern part of Browns but interest subsided as densities were low (1 - 2 t of logged catches) and meat size small. Mean CPUE derived from 1 - 2 t of logged catches of some TMS above 2 kg/crhm (Fig. 6) are not necessarily comparable to the most productive TMS figures because of the low catch representation.

The meat weight distribution in the catch (Table 15) varies greatly on an annual basis but the percentage examined is too small to draw any conclusion. Browns Bank catches have not been sampled after 1984 until the beginning of the experimental fishery. At-sea observers gathered meat samples (1 - 2 per watch) on a regular basis during trips and yielded better coverage of the catch size distribution than the regular sampling programme.Table 15 gives the average meat size during the experimental fishery at 8.9 g with a 0.01 s.d. Figure 7 profiles the meat weight frequency on a monthly basis. After going full tilt in September, the fishery came to an abrupt end in early

October before reaching the set quota because of the small meat size. The monthly histograms show quite well the radical decrease in modal size from September to October.

Previous surveys had found high concentrations of juveniles in a well delimited area of southeastern Browns Bank (Table 16). However, these year-classes did not contribute to a fishery revival. Very heavy mortality rates appear to have been experienced by possibly 3 successive year-classes of scallops on the southern edge of Browns Bank (Robert et al 1986). Both the 1986 and 1987 surveys established the paucity of pre-recruits and recruits. Survey work was not performed after that. It is interesting to relate the observed recruitment failure with the catch levels of 1 t reached in the area during the experimental fishery.

German Bank/Lurcher Shoals and the Outer Reaches of the Bay of Fundy

NAFO sub-subarea 4Xq includes German Bank and the lower half of the Lurcher Shoals (up to latitude 44 degrees North); the upper half of Lurcher Shoals is part of sub-subarea 4Xr. Statistical landings and logged catches for both fleets (Table 17) diverge for these respective areas illustrating the misrepresentation resulting from the statistical areas boundaries as presently set. Biological differences exist between German Bank and Lurcher Shoals; growth-rate being slower on German Bank relative to Lurcher Shoals and the outer reaches of the Bay of Fundy (Robert et al 1986).

During the recent exploitation of this area, the amount of fishable stocks steadily declined from its initial levels until 1985 (Table 17). Catch-rates were also following the same trends. A slight reversal of the downward trend appears to take place in 1986. The deep-sea fleet landed under 2 t. ; the Bay of Fundy fleet took relatively small quantities but at catch-rates similar to the high values encountered in 1979. In 1987 this fleet conducted only one fishing trip landing less than 1 t of meats at moderate catch-rates (7 kg/hm). No fishing activity is reported for 1988. As part of the experimental fishery, over 5 t were caught at a moderate CPUE. Sampling of the catch (Table 18) has been scanty or did not take place. The 1989 coverage suggests by the large meat weight (48 g) that the effort was expanded on remnants of the population that had sustained the German Bank fishery prior to 1985.

The abundance of large, old scallops was declining (Table 19) until the most recent survey. Very low levels of fishing activity took place between 1985-89. The annual stock survey did not extend to the German/Lurcher area after 1985.

Exploitation of scallop grounds in the outer reaches of the Bay of Fundy has been decreasing after the landing pulse of the early 1980s. Catch-rates have behaved similarly. Landings by both the Bay of Fundy and the deep-sea fleets had been minimal in 1986. However the deep-sea fleet managed a catch-rate (0.458 kg/crhm) comparable to values obtained during the initial stages of the recent fishery of these scallop beds. The Bay of Fundy fleet, the only fleet entitled to exploit the area beginning in 1987, has not fished these beds since.

CONCLUSION

Once again in 1989 scallop beds from the Scotian Shelf have contributed in an important way (20 %) to the total landings of the deep-sea fleet. 1989 witnessed the return of Browns Bank to significant exploitation levels in addition to the sustained production from the Western Bank / Sable Island area. Actually, the 500+ t caught in 1989 rank the year as an excellent one over the short catch history of the eastern Scotian Shelf. The experimental fishery conducted on the western Scotian Shelf with a size limit different from the Georges Bank one and a quota allowed a rationalised exploitaiton of scallop beds that would not have been realised otherwise. This exercise has shown the feasibility of having the western Scotian Shelf under a management plan different than the one of its more important neighbour, Georges Bank.

REFERENCES

Black, G.A.P. 1988. Manuscript. ACON - A shaded contour program for plotting irregularly spaced data. (Version 3.03). 50p.

Robert, G., M.J. Lundy and M.A.E. Butler-Connolly 1984. Recent events in the scallop fishery of the Bay of Fundy and its approaches. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 84/71, 41p.

Robert, G., M.J. Lundy and M.A.E. Butler-Connolly 1986. Scallop fishing grounds on the Scotian Shelf - 1985. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 86/41, 43p.

Robert, G., M.J. Lundy and M.A.E. Butler-Connolly 1987. Scallop fishing grounds on the Scotian Shelf - 1986. Can. Atl. Fish. Sci. Adv. Comm. Res. Doc. 87/26, 38p.

Watson, D.F. 1982. ACORD - Automatic contouring of raw data. Comp. & Geosci. 8: 97-101.

Watson, D.F. and G.M. Philip. 1985. A refinement of inverse distance weighted interpolation. Geo-Processing 2: 315-327.

Table 1.- Updated biological data on growth-rate and meat yield (year round values) for scallop fishing grounds on the Scotian Shelf. N = number of scallops examined.

	Growth	Yield
Banquereau Bank	N = 60	N = 90
	H_∞ = 128.105mm	intercept = -11.003
	t_0 = 1.5233	slope = 2.913
	k = 0.2579	
Middle Grounds	N = 414	N = 289
	H_∞ = 156.210mm	intercept = -10.305
	t_0 = 1.3650	slope = 2.801
	k = 0.1980	
Sable, Western Bank	N = 3,656	N = 3,674
	H_∞ = 136.710mm	intercept = -11.384
	t_0 = 1.3350	slope = 2.999
	k = 0.2264	
Browns Bank	N = 398	N = 420
	H_∞ = 114.046mm	intercept = -16.265
	t_0 = 1.3456	slope = 3.997
	k = 0.2636	

Table 2.- Number of vessels by fleet fishing scallop grounds on the Scotian Shelf as per log information.

Year	Bay of Fundy under 19.8m L.O.A.	Deep-sea over 19.8m L.O.A.	Total
1979	38	75	113
1980	37	75	112
1981	44	76	120
1982	45	75	120
1983	27	73	100
1984	29	50	79
1985	14	34	48
1986	32	55	87
1987	1	33	34
1988	0	17	17
1989	0	35	35

Table 3.- Fishery characteristics for the Banquereau Bank area (NAFO 4V) for the deep-sea fleet. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Effort pertaining to Class 1 catch only.

Year	Landings	Logged catches	Class 1 catch	Effort (crhm)	CPUE (kg/crhm)
1980	3.30	7.17	7.17	20,171	0.355
1981	0.00	0.00	–	--	–
1982	0.69	0.42	0.42	1,092	0.387
1983	5.37	3.26	3.26	7,343	0.444
1984	3.18	0.63	0.63	939	0.672
1985	0.24	N/A	N/A	N/A	N/A
1986	15.64	11.15	10.98	45,849	0.239
1987	0.65	0.51	0.51	4,617	0.110
1988	0.00	0.00	0.00	0,000	--
1989	0.00	0.00	0.00	0,000	--

Table 4.- Number of survey stations in NAFO SA 4V and 4W by year and by stratum type.

Banquereau Bank	1987	1988	1989
exploratory	5	5	6
total	5	5	6

Middle Grounds	1983	1984	1985	1986	1987	1988	1989
low catch	4	8	5	4	6	6	0
medium	4	-	-	-	-	-	-
high	12	12	5	6	6	-	-
total	20	20	10	10	12	6	0

Sable/Western Bank	1984	1985	1986	1987	1988	1989
low catch	14	7	13	5	4	11
medium	13	25	42	27	14	33
high	13	8	10	58	72	62
exploratory	-	-	10	-	-	-
total	40	40	75	90	90	106

Table 5.- Average number of scallops at age caught in a lined 2.44m New Bedford offshore dredge by catch stratum, in the western section of Banquereau Bank.

	Age (years)									Mean	s.d.
	2	3	4	5	6	7	8	9	10+		
1987 stock survey											
exploratory	0	0	0	1	9	4	1	1	1	18	25
1988 stock survey											
exploratory	0	0	0	0	7	8	1	1	0	17	30
1989 stock survey											
exploratory	0	0	0	0	0	0	0	0	5	8	13

Table 6.- Fishery characteristics for the Middle Grounds area (NAFO 4We) for the deep-sea fleet. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Effort pertaining to Class 1 catch only.

Year	Landings	Logged catches	Class 1 catch	Effort (crhm)	CPUE (kg/crhm)
1979	-	-	-	-	-
1980	3.65	1.42	1.42	5,434	0.262
1981	-	-	-	-	-
1982	72.39	62.09	61.12	122,106	0.501
1983	105.16	104.92	100.59	309,055	0.325
1984	11.90	9.94	8.34	47,585	0.175
1985	26.89	21.59	21.59	99,345	0.217
1986	51.27	51.28	50.46	345,552	0.146
1987	6.70	7.03	6.64	44,274	0.150
1988	0.28	0.29	0.29	1,707	0.169
1989	20.84	21.70	21.70	66,551	0.326
		Fishery characteristics for Sable Island and Western Bank (NAFO 4Wf-j)			
1979	-	-	-	-	-
1980	60.99	50.48	50.48	219,987	0.229
1981	0.56	0.00	0.00	0	-
1982	64.10	61.40	61.40	243,779	0.252
1983	185.15	166.47	164.45	886,072	0.186
1984	71.30	64.65	63.58	370,231	0.172
1985	64.93	76.00	76.00	294,217	0.258
1986	618.35	585.26	551.88	3,070,138	0.180
1987	415.80	412.01	394.23	2,339,915	0.168
1988	100.43	100.42	93.99	414,920	0.227
1989	516.39	515.36	489.54	1,830,668	0.267

Table 7.- Nature of the catch from NAFO SA 4W determined by the analysis of scallop meat weights.

	% catch examined / catch landed	meat weight (g) mean	min	max	s.d.	n meats
Middle Grounds						
1983	0.0240	20.00	3.04	69.99	0.13	1259
1984	0.0392	14.84	4.23	46.97	0.14	314
1985	0.0175	22.88	6.31	66.40	0.22	217
1986	0.0134	22.73	4.33	61.51	0.23	302
1987	0.0436	21.48	2.34	68.23	0.30	137
1988	-	-	-	-	-	-
1989	0.0441	14.46	4.22	61.45	0.11	636
Sable Island/Western Bank						
1980	0.0133	9.46	3.87	22.11	0.04	860
1981	-	-	-	-	-	-
1982	0.0015	9.15	4.65	15.38	0.11	102
1983	0.0339	13.49	2.25	72.43	0.04	4658
1984	0.0161	11.10	2.65	42.48	0.07	1034
1985	0.0025	27.41	11.27	54.30	0.52	62
1986	0.0271	15.03	2.33	79.13	0.03	11397
1987	0.0319	14.35	2.22	98.14	0.04	9226
1988	0.0045	11.57	4.07	34.60	0.09	394
1989	0.0215	13.14	3.16	72.91	0.02	8440

Table 8.- Average number of scallops at age caught in a lined 2.44m New Bedford offshore dredge by catch stratum, Middle Grounds.

	Age (years)									Mean	s.d.
	2	3	4	5	6	7	8	9	10+		
1983 stock survey											
low	0	0	0	1	0	0	0	0	0	2	2
medium	0	0	2	13	8	1	0	0	2	26	15
high	0	0	3	31	9	0	0	0	1	55	67
1984 stock survey											
low	0	0	0	2	1	2	1	0	0	8	10
high	0	0	0	2	6	4	2	1	2	17	16
1985 stock survey											
low	0	0	3	6	2	4	1	0	0	20	23
high	0	0	0	0	0	3	3	0	1	10	13
1986 stock survey											
low	0	0	0	0	0	0	1	1	3	7	7
high	0	0	1	0	3	6	4	2	2	17	10
1987 stock survey											
low	0	2	0	1	1	0	0	1	2	6	8
high	0	0	0	0	0	1	1	0	3	6	4
1988 stock survey											
exploratory	5	10	16	4	2	1	1	1	2	51	56

Table 9.- Summary of average number of scallops at age caught for prerecruits, shell height under 75mm or age less than 5 years, and recruits, shell height over 75mm by catch stratum, for Banquereau Bank and the Middle Grounds area.

	Age (years)		
	2-4	5-10	11+
Banquereau Bank			
1987 stock survey exploratory	0	16	1
1988 stock survey exploratory	0	17	0
1989 stock survey exploratory	0	1	4
Middle Grounds			
1983 stock survey			
low	0	1	0
medium	2	23	1
high	3	40	1
1984 stock survey			
low	0	6	0
high	0	16	1
1985 stock survey			
low	3	13	0
high	0	6	1
1986 stock survey			
low	0	4	1
high	1	16	1
1987 stock survey			
low	2	4	1
high	0	3	2
1988 stock survey exploratory	31	10	1

Table 10.- Average number of scallops at age caught in a lined 2.44m New Bedford offshore dredge by catch stratum, Sable Island - Western Bank area.

	Age (years)									Mean	s.d.
	2	3	4	5	6	7	8	9	10+		
1985 stock survey											
low	71	55	27	15	12	7	6	2	9	205	222
medium	9	15	16	7	6	6	5	2	7	74	59
high	59	112	40	33	24	6	4	2	0	281	181
1986 stock survey											
low	1	3	2	2	1	0	1	1	5	15	15
medium	2	2	4	2	2	1	1	1	6	20	30
high	1	0	1	1	1	1	2	2	6	13	9
exploratory	0	0	0	0	0	0	0	0	1	3	2
1987 stock survey											
low	0	1	2	2	1	1	1	1	5	14	12
medium	2	4	6	9	6	2	1	1	6	37	51
high	12	23	35	34	16	5	3	2	5	134	149
1988 stock survey											
low	1	2	1	0	0	0	0	1	3	7	4
medium	3	6	8	11	10	4	1	1	4	48	70
high	25	41	48	50	29	10	3	2	3	210	222
1989 stock survey											
low	3	8	5	7	3	2	0	0	3	33	57
medium	0	2	4	7	6	3	1	1	4	28	38
high	8	34	50	42	24	10	4	1	2	181	229

Table 11.- Summary of average number of scallops at age caught for prerecruits, shell height under 75mm or age less than 5 years, and recruits, shell height over 75mm by catch stratum, Sable Island - Western Bank area.

	Age (years)		
	2-4	5-10	11+
1984 stock survey			
low	10	14	4
medium	32	21	3
high	16	28	2
1985 stock survey			
low	153	43	8
medium	40	27	6
high	212	69	0
1986 stock survey			
low	6	5	5
medium	8	8	5
high	2	8	5
exploratory	0	0	1
1987 stock survey			
low	3	6	5
medium	12	20	5
high	70	61	4
1988 stock survey			
low	4	2	2
medium	17	28	3
high	114	95	2
1989 stock survey			
low	16	12	3
medium	6	19	3
high	92	82	1

Table 12.- Extent of the area where scallop beds were surveyed on Sable / Western during research stock surveys.

	Area surveyed in km ^{2}			
	1986	1987	1988	1989
Western Bank	3,726.38	5,944.07	3,891.46	5,889.65
Above Sable Island	339.48	19.14	-----	60.84
Below Sable Isand	175.57	-----	-----	-----
Total	4,241.43	5,963.21	3,891.46	5,950.49

Table 13.- Volume estimates in n (10^6) for the Western Bank area derived from research survey data.

	Age (years)					
	2	3	4	5	6	7
1986	1.69	2.10	3.52	3.34	3.17	0.89
1987	17.03	34.63	57.72	44.74	20.79	7.92
1988	24.22	46.05	54.10	56.36	32.81	11.38
1989	5.76	24.81	43.42	42.46	23.34	12.18

Table 14.- Fishery characteristics for the Browns Bank - Tusket area (NAFO 4Xp and 4Xo) for the deep-sea fleet. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Effort pertaining to Class 1 catch only.

Year	Landings	Logged catches	Class 1 catch	Effort (crhm)	CPUE (kg/crhm)
4Xo					
1979	0.00	13.70	13.70	21,964	0.624
1980	13.17	40.79	33.41	60,979	0.548
1981	0.36	1.40	1.40	2,219	0.632
1982	47.55	70.87	65.76	86,204	0.763
1983	42.78	53.11	44.96	78,613	0.572
1984	10.57	13.24	13.24	45,619	0.290
1985	0.00	0.84	0.84	2,155	0.389
1986	0.00	0.00	0.00	0	-
1987	0.00	0.00	0.00	0	-
1988	4.22	0.00	0.00	0	-
1989	16.14	42.31	35.04	44,918	0.780
4Xp					
1979	73.05	77.90	76.62	145,118	0.528
1980	258.23	205.91	199.25	479,388	0.416
1981	24.98	12.86	12.65	19,578	0.646
1982	114.07	83.40	82.84	217,580	0.381
1983	63.32	34.83	33.46	135,526	0.247
1984	16.60	4.95	4.95	26,565	0.186
1985	6.93	15.54	15.54	36,413	0.427
1986	4.64	4.00	4.00	6,948	0.576
1987	0.00	0.00	0.00	0	-
1988	0.00	5.16	5.16	2,853	1.808
1989	321.20	277.76	189.98	287,667	0.660

Table 15.- Nature of the catch from Browns Bank/Tusket area determined by the analysis of scallop meat weights.

	% catch examined	meat weight (g)			
	catch landed	mean	min	max	s.d.
1979	0.0022	16.29	4.01	58.66	0.18
1980	0.0195	10.54	1.37	87.46	0.04
1981	0.0080	35.75	13.71	55.37	0.35
1982	0.0020	16.39	2.90	47.13	0.18
1983	0.0000	---	---	---	---
1984	0.0062	21.98	6.46	68.63	0.51
1985	0.0000	---	---	---	---
1986	0.0000	---	---	---	---
1987	0.0000	---	---	---	---
1988	0.0000	---	---	---	---
1989	0.0388	8.93	3.70	49.90	0.01

Table 16.- Summary of average number of scallops at age caught for prerecruits, shell height under 75mm or age less than 5 years, and recruits, shell height over 75mm by catch stratum.

	Age (years)		
	1-4	5-10	11+
Browns Bank / Tusket 1983			
low	416	6	1
high	308	9	7
Browns Bank / Tusket 1984			
low	0	0	0
medium	156	11	11
high	61	34	1
Browns Bank / Tusket 1985			
exploratory	247	6	11
low	0	0	0
high	1	0	2
Browns Bank / Tusket 1986			
exploratory	1	8	4
low	0	0	1
high	1	0	1
Browns Bank / Tusket 1987			
exploratory	12	2	2

Table 17.- Fishery characteristics for the German Bank/Lurcher Shoals area (NAFO 4Xq) for both fleets. Landings and catches are in t of scallop meats. Landings are from Statistics Division, Fisheries and Oceans, Halifax. Effort pertaining to Class 1 catch only. (In parenthesis, catches supported by sales slips only.)

Bay of Fundy fleet Year	Landings	Logged catches	Class 1 catch	Effort (hm)	CPUE (kg/hm)
1979	293.82	258.25	182.37	7,112	25.64
1980	113.72	89.91	65.96	6,485	10.17
1981	194.73	185.51 (46)	125.57	14,352	8.75
1982	99.06	119.11 (16)	78.11	12,348	6.33
1983	43.68	32.30 (6)	16.76	5,949	2.82
1984	11.07	32.90	25.29	7,660	3.30
1985	2.80	1.45	0.30	416	0.71
1986	23.94	34.62	22.41	1,085	20.66
1987	0.66	0.41	0.41	57	7.09
1988	0.00	0.00	0.00	00	-----
1989	0.00	0.00	0.00	00	-----

Deep-sea fleet Year	Landings	Logged catches	Class 1 catch	Effort (crhm)	CPUE (kg/crhm)
1979	102.32	147.10	145.20	157,729	0.921
1980	1269.71	1132.69	1021.86	1,614,441	0.633
1981	379.69	207.63	188.78	318,221	0.593
1982	659.74	535.84	403.51	954,628	0.423
1983	587.76	465.88	420.45	1,092,569	0.385
1984	207.13	175.83	156.45	581,969	0.269
1985	33.76	16.60	15.91	46,295	0.344
1986	1.59	0.00	0.00	0	---
1987	0.00	0.00	0.00	0	---
1988	0.00	0.00	0.00	0	---
1989	5.54	4.54	4.01	9,112	0.440

Table 18.- Nature of the catch from German Bank/Lurcher Shoals area determined by the analysis of scallop meat weights.

	% catch examined	meat weight (g)			
	catch landed	mean	min	max	s.d.
1979	0.0019	11.39	4.74	34.15	0.06
1980	0.0135	11.66	2.20	85.82	0.02
1981	0.0084	12.74	2.34	75.27	0.04
1982	0.0171	16.04	3.69	76.92	0.03
1983	0.0010	11.99	3.35	44.13	0.11
1984	0.0008	22.69	3.88	53.52	0.42
1985	0.0000	-	-	-	-
1986	0.0000	-	-	-	-
1987	0.0000	-	-	-	-
1988	0.0000	-	-	-	-
1989	0.1012	47.93	27.41	76.19	0.32

Table 19 - Summary of average number of scallops at age caught for pre-recruits, shell height under 75mm or age less than 5 years, and recruits, shell height over 75mm by catch stratum.

	Age (years)		
	1-4	5-10	11+
German Bank / Lurcher Shoals 1983			
low	0	15	8
medium	0	36	9
high	0	35	8
German Bank / Lurcher Shoals 1984			
low	0	15	3
medium	0	29	5
high	0	38	6
German Bank / Lurcher Shoals 1985			
low	0	6	7
medium	0	17	5
high	0	24	3

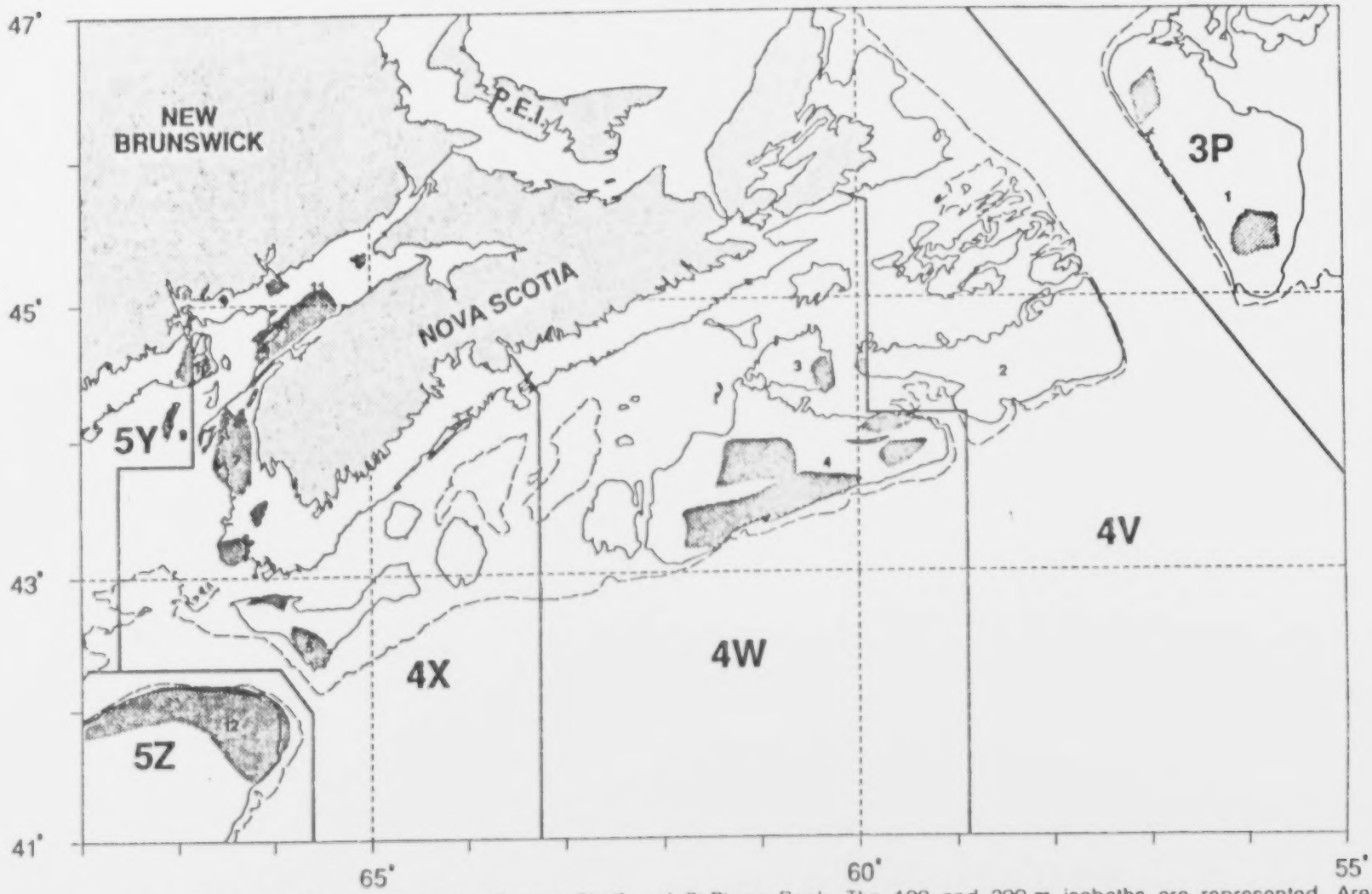

Figure 1.- Scallop fishing areas on the Scotian Shelf and St.Pierre Bank. The 100 and 200-m isobaths are represented. Areas in numerical order are: (1) St.Pierre Bank; (2) Banquereau Bank; (3) Middle Ground; (4) Sable Island area; (5) Browns Bank; (6) German Bank; (7) Lurcher Shoals; (8) Outer reaches of the Bay of Fundy; (9) Southwest Bank; (10) Grand Manan area and (11) the Bay of Fundy area. Georges Bank is also shown.

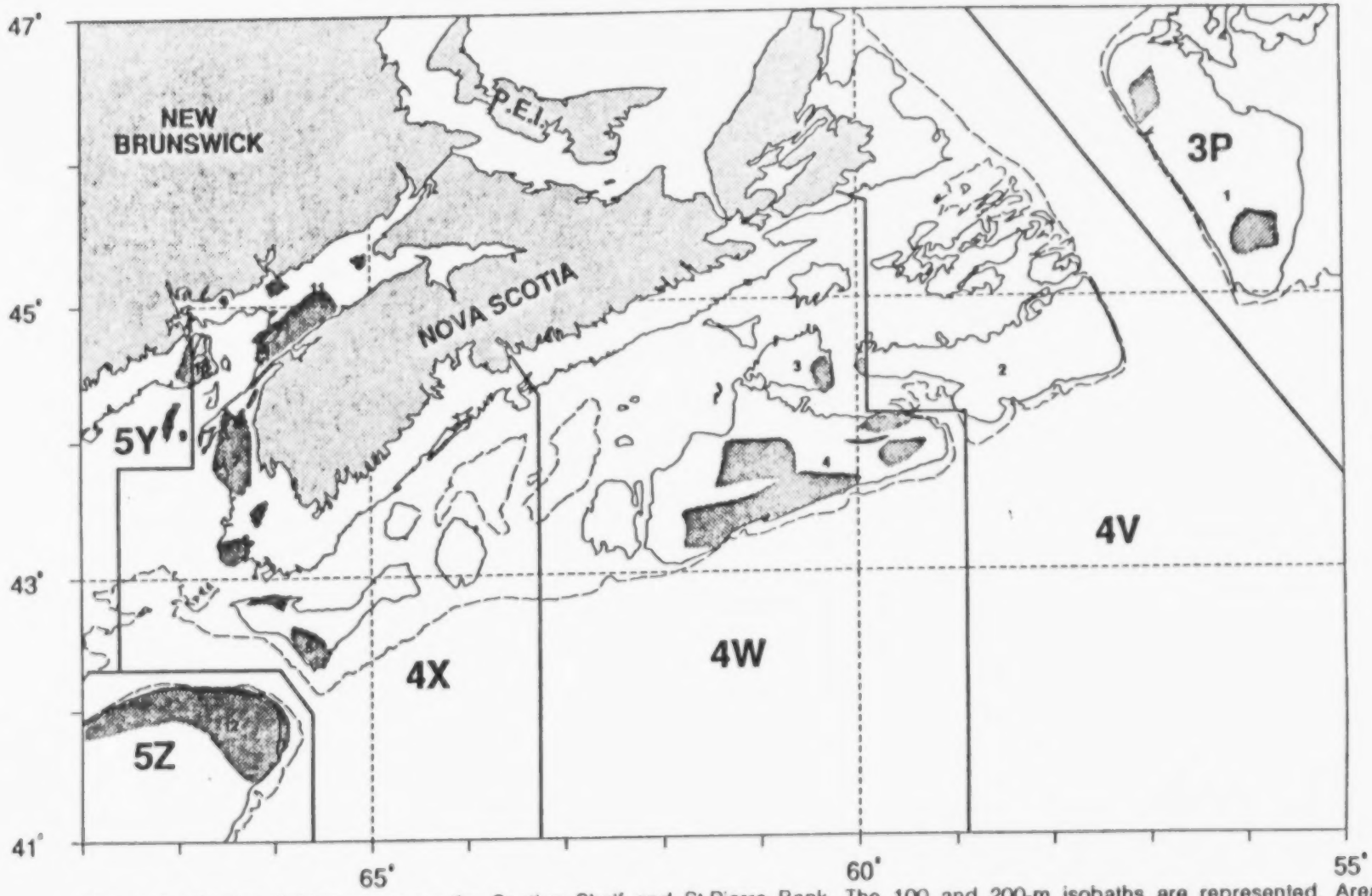

Figure 1.- Scallop fishing areas on the Scotian Shelf and St.Pierre Bank. The 100 and 200-m isobaths are represented. Areas in numerical order are: (1) St.Pierre Bank; (2) Banquereau Bank; (3) Middle Ground; (4) Sable Island area; (5) Browns Bank; (6) German Bank; (7) Lurcher Shoals; (8) Outer reaches of the Bay of Fundy; (9) Southwest Bank; (10) Grand Manan area and (11) the Bay of Fundy area. Georges Bank is also shown.

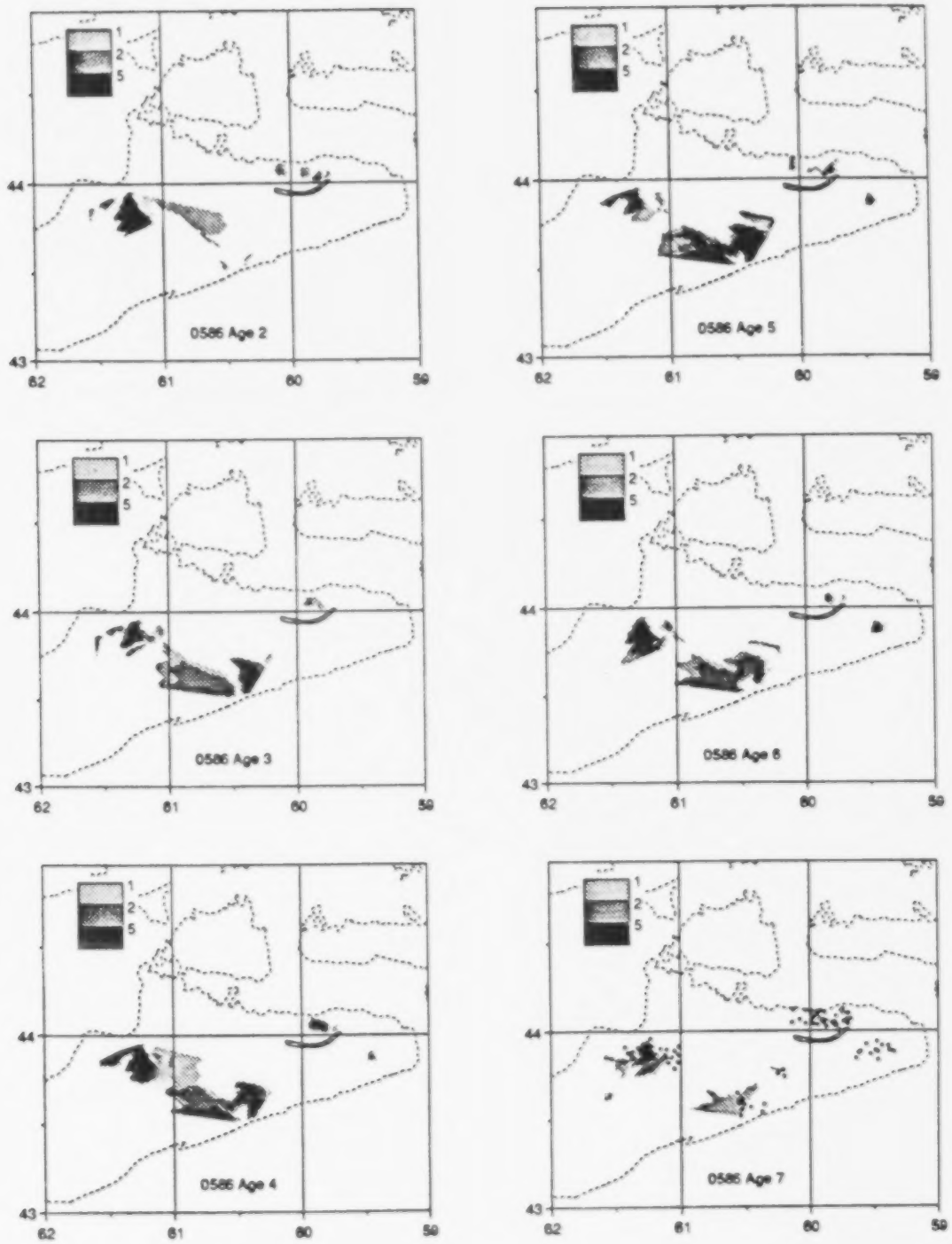

Figure 2.- 1986 survey catch-rates. Scallop distribution and density for selected ages illustrated by shaded contours. Density is expressed in numbers per standard tow; increasing shades of grey correspond to greater abundances (see grey scale in upper corner of the plot). The contour plot for age 7 shows the data points.

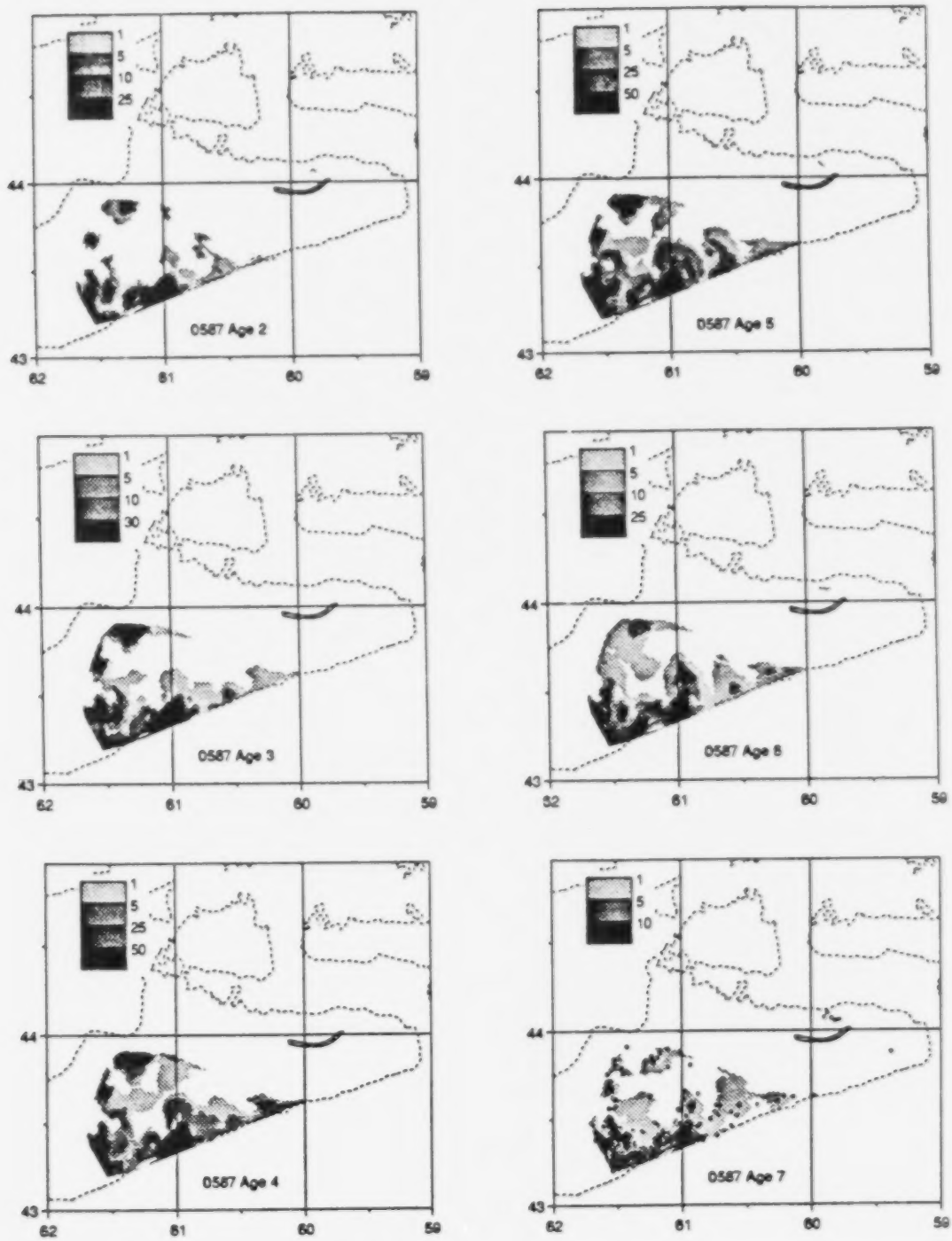

Figure 3.- 1987 survey catch-rates. Scallop distribution and density for selected ages illustrated by shaded contours. Density is expressed in numbers per standard tow; increasing shades of grey correspond to greater abundances (see grey scale in upper corner of the plot). The contour plot for age 7 shows the data points.

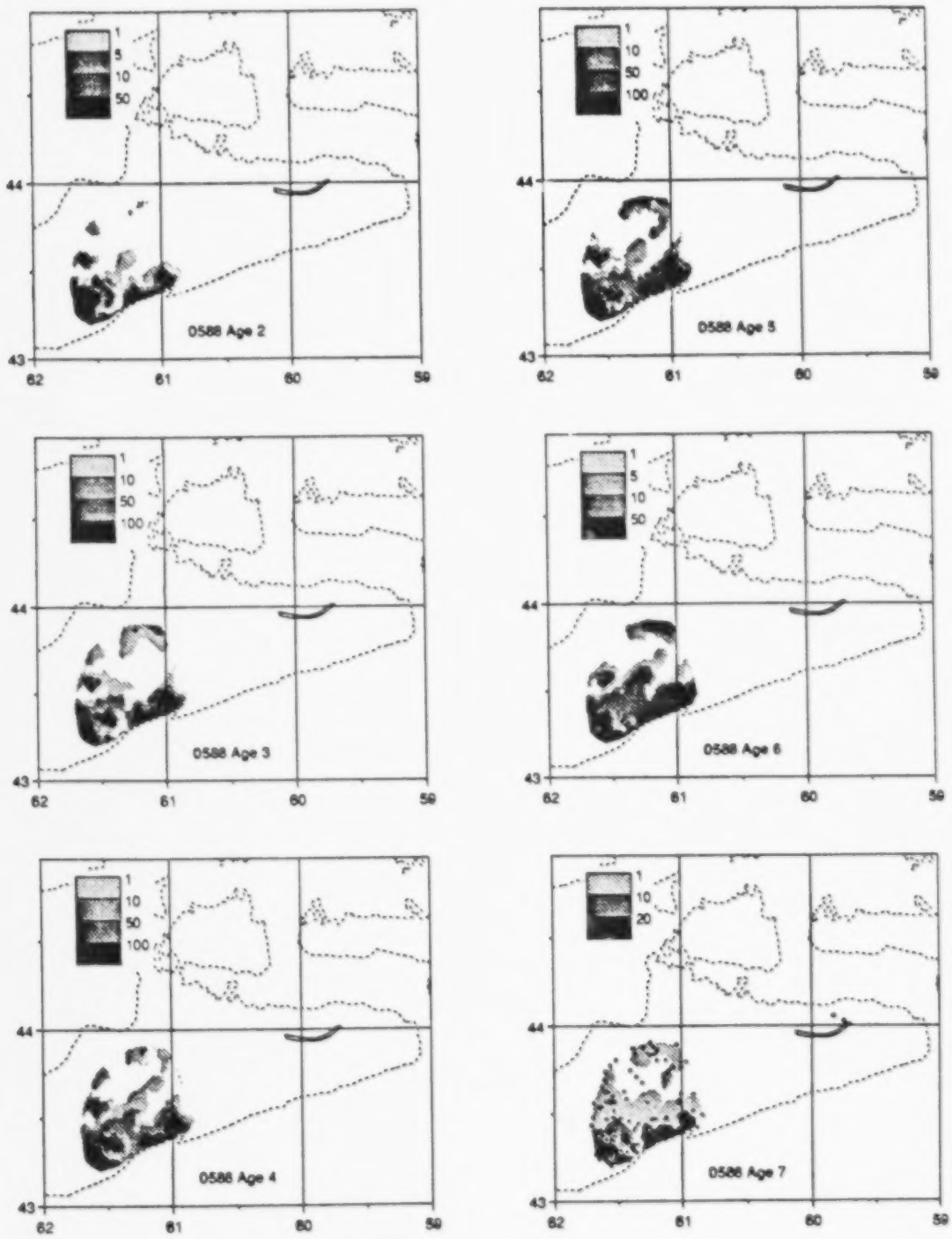

Figure 4.- 1988 survey catch-rates. Scallop distribution and density for selected ages illustrated by shaded contours. Density is expressed in numbers per standard tow; increasing shades of grey correspond to greater abundances (see grey scale in upper corner of the plot). The contour plot for age 7 shows the data points.

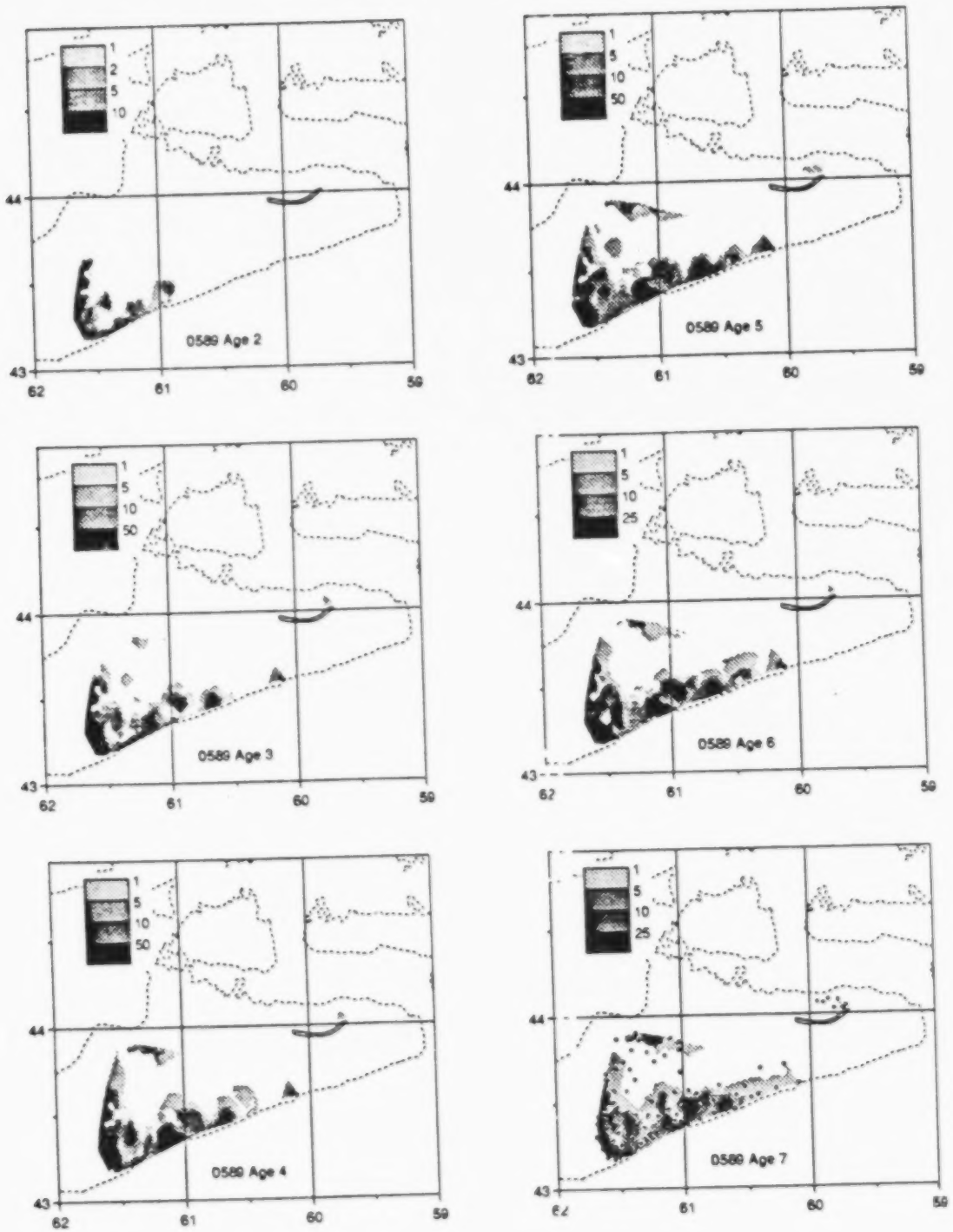

Figure 5.- 1989 survey catch-rates. Scallop distribution and density for selected ages illustrated by shaded contours. Density is expressed in numbers per standard tow; increasing shades of grey correspond to greater abundances (see grey scale in upper corner of the plot). The contour plot for age 7 shows the data points.

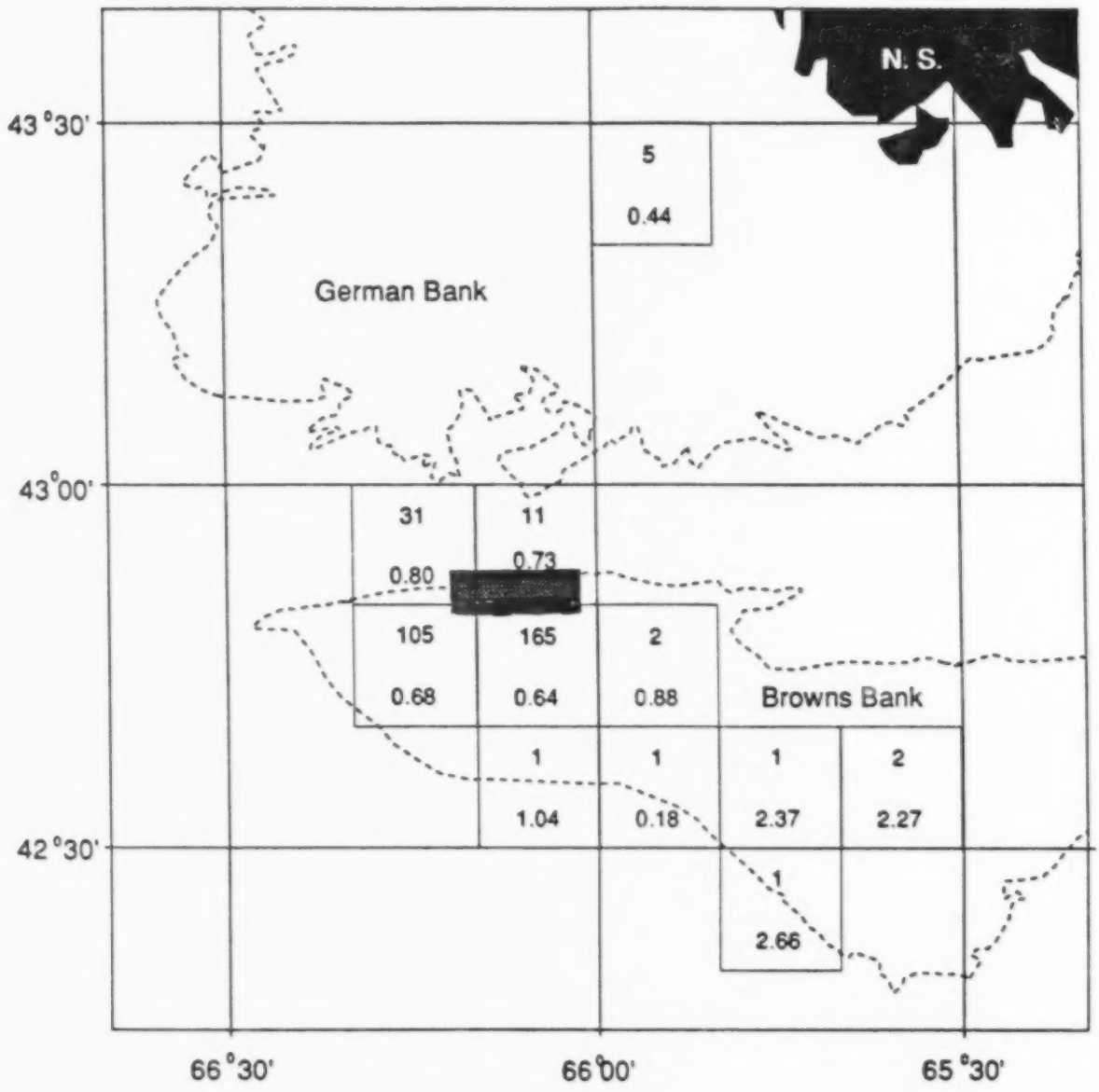

Figure 6.- Location of the 1989 fishery on the western Scotian Shelf. Fishing activity has been segmented into Ten-Minute Square (TMS) boxes with logged catches (t) in the upper half of each TMS, the CPUE (kg/crhm) in the bottom half. The shaded rectangle on the northern edge of Browns Bank outlines the section where most of the effort was concentrated.

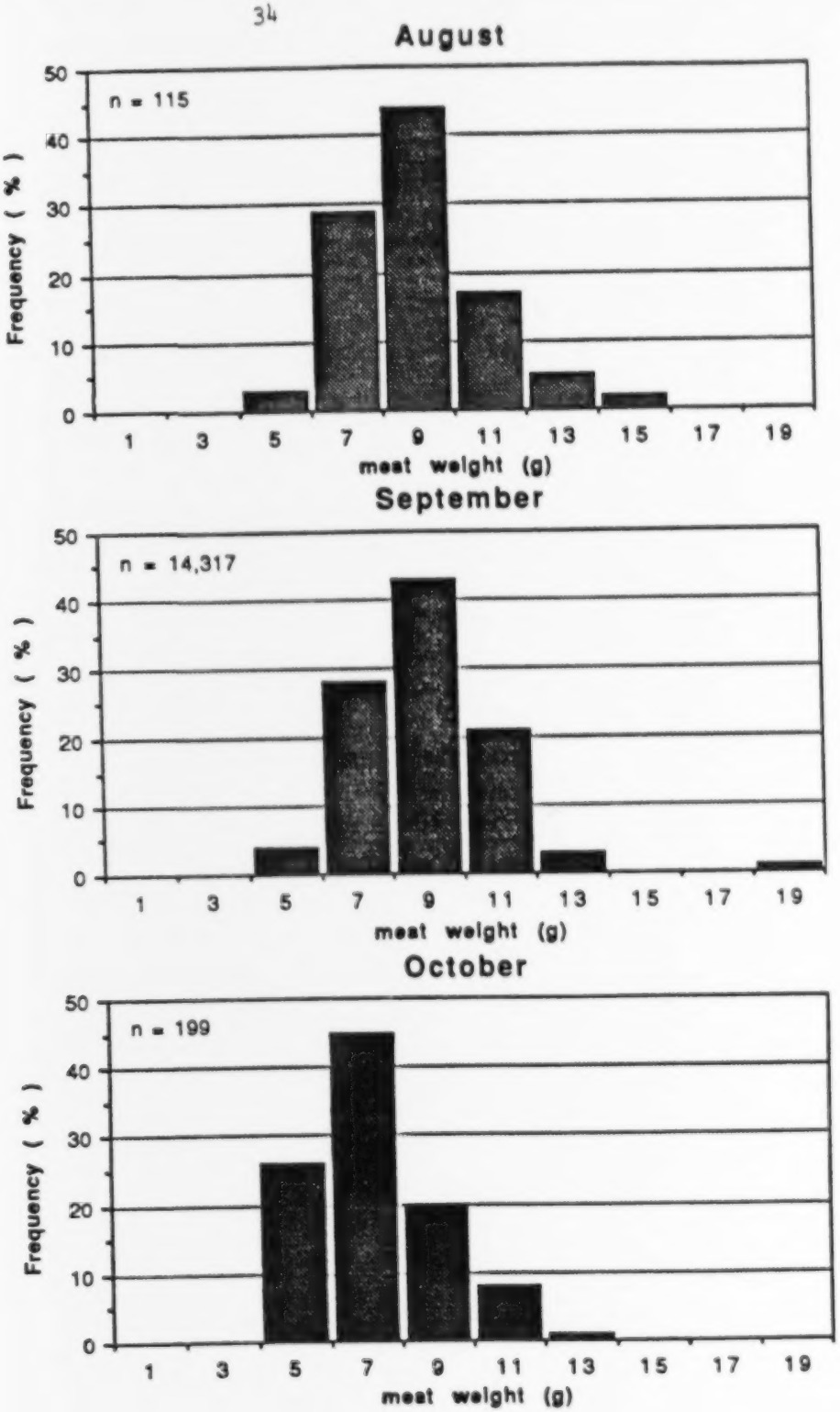

Figure 7.- Meat weight distribution in the 1989 Browns Bank experimental fishery as a percent frequency of the monthly total meats (n).